



# Why the Lack of Academic Literature on Export Controls?

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# Why the Lack of Academic Literature on Export Controls?

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## Abstract

Export controls is currently a relevant and dynamic topic. Given the growth of global operations and the high-tech nature of many products, an increase in awareness and understanding of the impacts of export controls are necessary. A structured approach to export controls has been in existence since 1949. Despite over 50 years of history, surprisingly little **academic** research and literature exists on the topic. This paper explores the current export control environment and explores possible reasons for the limited academic interest. Five possible reasons are discussed: (1) dynamic nature of the topic, (2) difficulty in ensuring accurate data, (3) complexity of the problem, (4) relatively small economic impact, and (5) sensitive information. A research approach is recommended that considers these potential obstacles.

## Background

Export controls is currently a very charged and dynamic topic. In the broadest sense, export control is considered as actions taken to limit the diffusion of certain technologies or products to foreign entities. Export control, as further discussed in this paper, is defined more precisely as the regulatory restrictions placed on domestic individuals or entities in order to limit the flow of specified products, technologies, and capabilities to undesired foreign entities.

The concept of protecting advantageous from potential enemies has existed for centuries.<sup>6</sup> The competitive and sometimes adversarial nature of man and the need for self-preservation have resulted in a security anxiety among people and their governments. Following World War II, the U.S. government has pursued a systematic and arguably organized approach to controlling technologies that it perceives as providing a national security advantage. With the establishment of NATO in 1949, and the Coordinating Committee for Multilateral Export Controls (CoCom),<sup>1</sup> export controls became an international regulatory topic. Allied nations have since sought to individually protect their national security and collectively partner to withhold advanced capability from non allied nations, particularly those following aggressive military and terrorist policies.

Identification and control of technologies important to national security has become increasingly difficult with the remarkable growth of knowledge in technical fields such as electronics and microprocessors,<sup>2</sup> software, chemicals/materials, systems integration, communication, aerospace, bioengineering, and others. Modifications to export control policy are occurring more and more frequently.<sup>2</sup> Currently, reviews of existing regulations are required every 6 months for high-performance computing (HPC) controls.<sup>3</sup> This, again, is a reflection of the rapid growth of technology.

## **Two forces**

There are two basic camps; one on either side of the export control battlefield. One carries the banner of national security and the other the banner of economic viability. Proponents of stricter export controls point to the fragmentation of potential enemies after the collapse of the Iron Curtain as an even stronger impetus for control. Allegations of spying by China and illegal exports to India heat the fuels of national security.<sup>15</sup> They recount the successes of modern technology in combat situations such as the Gulf War and conflicts in the former Yugoslavia. They believe control by the United States and its allies must be increased if a long-term advantage is to be maintained. They perceive the other camp as greedy businesses, or in some cases politicians,<sup>4</sup> that are willing to sell the country for a profit. Studies that claim harmful impacts to business are challenged.<sup>27</sup> Better control is the preferred method of ensuring U.S. technological edge.

Those seeking to loosen export controls argue that export control systems are built on Cold War mentality. Controls arbitrarily restrict domestic firms from participating in international markets. Further, the controls are often based on inconsistent and outdated measures of technology. They point to restrictions on encryption and demonstrate that stronger encryption products are available from foreign sources via the Internet than are permitted to be sold by U.S. producers (without export licenses).<sup>6</sup> They point to HPC regulations that limit sales of computers that can easily be made from products sold in mass by sources in Asia.<sup>2</sup> The economic perspective argues that the way to ensure future competitive military advantage is to allow business to prosper through early marketing of its capabilities and the higher profits that result. The Clinton administration had the following formula for strong defense: exports = healthy high-tech companies = strong defense.<sup>3</sup> Instead of the military spinning off technology products, it is now buying the products from commercial suppliers. Restricting the suppliers' markets will diminish their capability and harm a much-desired military advantage.<sup>1,5</sup> Per a U.S. News and World Report article, "defense firms must sell globally to stay in business."<sup>18</sup> This camp believes that the way to ensure national security is to be faster at developing technology than foreign competitors, through reinvesting profits gained in foreign sales.

Neither camp claims that the goals of the other are incorrect. Both camps want national security and strong economic performance of domestic firms. The difference lies in one's approach and perspective of where the proper balance is between free trade and maintaining technological advantage in areas important to national security.

## **Current export control system**

Current export control systems are complex even though they have been simplified a great deal in the last few years. The complexity exists for several reasons. First, there is no one organization that is responsible for all of export control. The Department of Commerce, through the Bureau of Export Administration (BXA), plays a coordinating role and regulates most exports.<sup>7, 9, 19</sup> They administer the commercial export control processes in conjunction with the Departments of Defense and State, the Nuclear Regulatory Commission (NRC), and others. The State Department regulates military products. Any shipment of products on the State Department list requires a license; Canadian shipments being an exception.

A second confounding factor is the dynamic nature of the technology in question. Technology changes ever faster and therefore controls are more difficult to keep current.<sup>1</sup> New technologies that have national security implications must quickly be identified. An even more difficult task is determining what level of control should be set to allow capitalization by domestic entities but protection from undesirables. For example, debate continues on satellite exports and exports of “space qualified” items.<sup>8, 11</sup>

A third complicating factor is the political nature of the subject. Domestically, there is the natural tension between security and economic growth. Internationally, there are the relationships between the United States and its allies, between the United States and its adversaries, among allied nations, and finally amongst other allied nations and U.S. adversaries.<sup>12, 13</sup> Adversaries, however, are not unanimously defined,<sup>14</sup> nor do they remain constant. The United States may be protecting something that our ally is giving away, or worse, selling at high profits despite multilateral export agreements.

Current export control policy appears to control on two dimensions. These are end user/end use and technology or product. The end user/end use dimension bases controls on what entity and country is ultimately receiving the technology and what they intend to do with it. Technology in this case represents products, capital equipment, and capability / know-how. BXA defines technology as “specific information necessary for the development, production, or use of a product.”<sup>16</sup>

There are several categories of end users/end uses. There are military versus commercial users, restricted parties, special entities, and finally tier countries. In general, tighter controls are enacted for military end users. Also requiring export licenses are shipments to organizations on the Entity List (EL). Exports are simply prohibited to restricted parties, which are often on this list for prior export control violations. Country tier status dictates the level of export control placed on computers to the subject country. There are four tiers with the closest allies of the United States in Tier 1 and the most adversarial in Tier 4. Tier 4 countries include Iran, Cuba, Libya, Sudan, Syria, North Korea, and Iraq.

End users are monitored to ensure compliance with export licenses. Government agents conduct unannounced inspections of user sites. End users must verify that the goods are being used as filed in the export license. There has been a dramatic increase in the attention given to export control enforcement. In the last 2 years, the number of agents assigned to this task has increased nearly 40 percent.<sup>17</sup>

The other dimension of export control is the technology/product. The State Department controls products that are designed, or could be modified, for military use. Licenses are required for shipments of any product on the State Department list to essentially any country. Controversy exists over the contents of this controlled products list.<sup>8, 11</sup> This stems from the fact that modern products often contain microprocessors and electronics or include other technologies that could have military application.<sup>1, 2</sup> The computer that makes the bread could conceivably be used to trigger an explosion. A current example of this controversy can be found on the BXA Web site. In April/May of 2000, a review panel will decide whether or not to move certain items from the Commerce List to the State Department list. These items are space-related goods such as

Photovoltaic arrays, (which can also be used for power generation in villages in underdeveloped countries), radio equipment, solid-state detectors, and other similar products. A source of potential confusion can be found even in this short list. Radio and solid state sensors are commonly used in process and production facilities and do not necessarily have a military application, yet would be controlled as such if transferred to State Department jurisdiction. Additional controversy exists with the sales of conventional arms. Historically the United States has been the world's top exporter of arms.<sup>25</sup>

In addition to military/dual use items, several other categories of controlled products exist. The most important include (1) encryption, (2) high-performance computers, (3) capital equipment, (4) chemical and biological substances, and (5) deemed exports.

Encryption technology relates to securing of communications and data to make it unreadable by others. The issue with encryption is that U.S. security and law enforcement agencies want to be able to decipher foreign and domestic information but not have secure US communications compromised. Strong encryption technology is being developed that cannot be readily decoded. If crime organizations, terrorists, and rogue nations use this technology, it will be more difficult for the United States to combat the threats. The business side of the problem is the need for secure economic and personal information transfer, particularly financial transaction data. Legitimate businesses should use strong encryption to protect valuable data, but ideally these encryption tools should not be available to organized crime, terrorists, and the like. Debates on encryption have been active in the recent past and will remain so until the industry settles around the newly framed policy released in September of 1999. The new policies are portrayed as simple market-driven rules. In brief, the current requirements are a review of products before sale, a post-sale report on distribution, and a review of sales to foreign governments. Recent changes include: (1) encryption software can now be shipped to any non government user excluding Tier 4 countries, (2) products labeled as "retail" can also be shipped to most countries, (3) licenses for Internet providers and telecommunications firms are not required, and (4) any encryption technology freely available does not require a technical review.<sup>3, 20</sup> The "looser" nature of the policy is obvious. Current control philosophy is radically different from what it was just a couple years ago<sup>10</sup> when the control direction had been toward bit length restrictions and "keys." That seems to have fallen completely aside. Apparently, there has either been a strong lobby effort by the telecommunications and electronic commerce industries or new technology has recently become available that has changed the encryption rules. How much simpler the new framework is remains to be seen. Will the reviews bog down sales? Will the controls keep strong encryption technology from foreign governments when the local businesses are permitted to own it? These are the issues that will likely keep encryption on export control agendas.

HPC restrictions are based on the processing ability of microprocessors. The faster the computers, the better they can design, study, simulate, and control weapons. As mentioned, reviews of the current policy occur regularly. Changes generally amount to the movement of countries between the tiers and the raising of MTOPS limits. For example, effective August 1999 the computing power exportable to Tier 2 countries without a license doubled from 10000 MTOPS to 20000 MTOPS. As a comparison, an early Pentium processor could perform at roughly 60 MTOPS. Refer to Figure 1.<sup>2</sup> The same update moved Brazil, Hungary, Czech Republic, and Poland to Tier 1 status.<sup>21</sup> Military end users have tighter controls and the



computing power exportable to them is in general lower than what is saleable to commercial users. The end user restrictions tighten even further when the end user is involved in missile, biological, or chemical weapons. Adding to the difficulty of HPC controls is the scalable nature of today's computer technology. With networking and parallel processing even moderately powerful computers can be configured to achieve supercomputer performance. Paralleling capability is an area of continued concern for export officials.

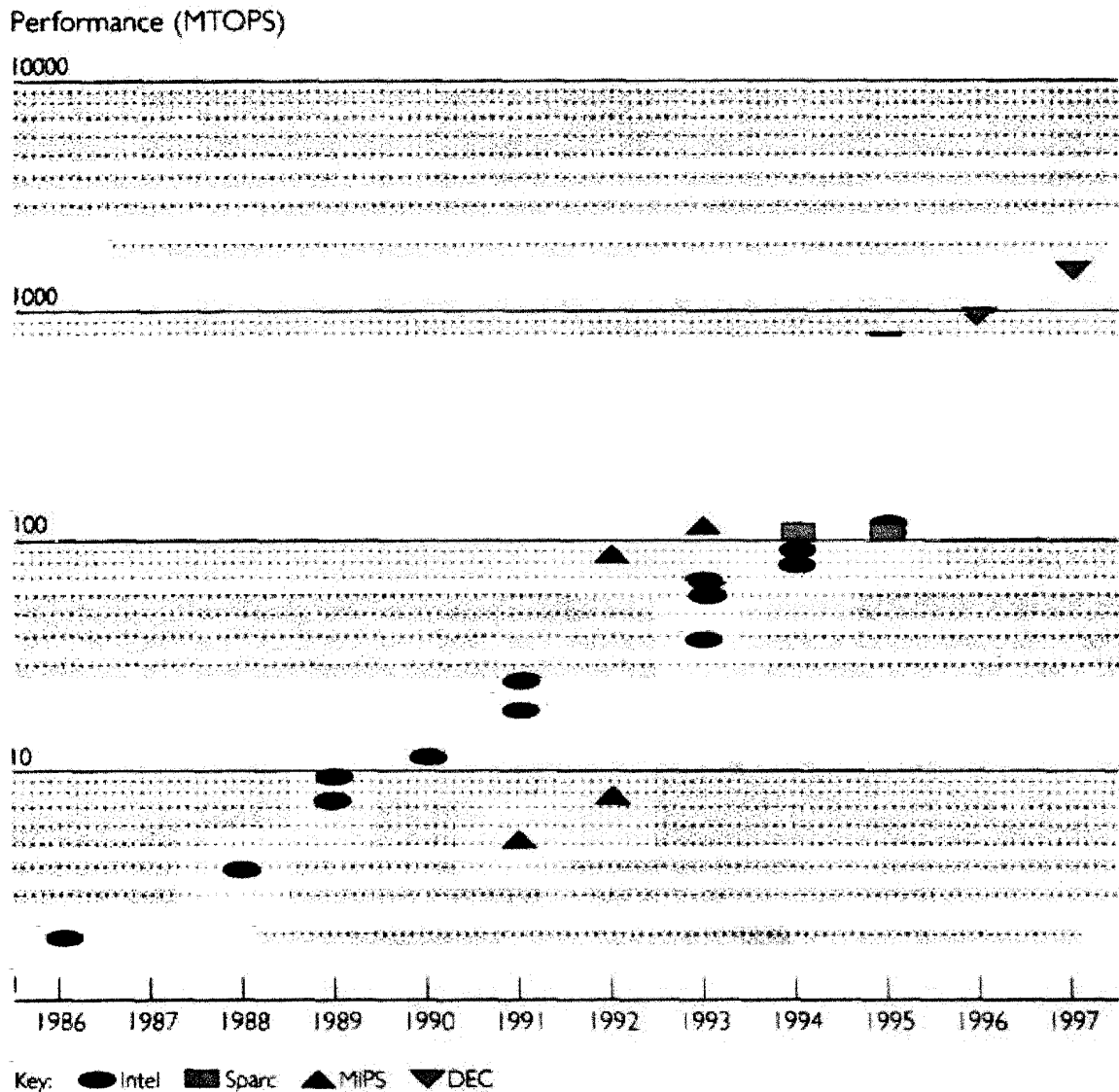


Figure 1. Computing performance<sup>2</sup>

Capital equipment is the area where most export license denials occur. In fact, more than half of all denials in 1999 were related to capital equipment.<sup>14</sup> Capital equipment includes machinery and related process equipment. The obvious threat is the transfer of the **ability** to make threatening products. The sale of controlled products is one thing, but a more serious concern is

when the foreign entity can make the threatening weapons themselves and perhaps forward them to others. Focus of controls by export officials is moving towards capital equipment and less on mass-produced products.<sup>14</sup> This maneuver will not come without challenge. In fact, the government has come under criticism for inappropriate control of machinery. Kuttner points out that Russia has historically been one of the world's largest importers of machine tools/capital equipment. In 1988, Russia imported \$1 billion dollars worth of machinery, most of it supplied by Germany. In that year, the U.S. share of the \$1 billion totaled only \$1.3 million! It is said that Russia's machine display at a U.S. tool show included equipment that the United States could not export to them!<sup>1</sup> Although controlling the ability to produce advanced parts may make sense to some regulators and security proponents, the machine tool industry will inevitably argue that it will hurt U.S. toolmakers and also be an ineffective tactic because German and Japanese competitors will supply the demand anyway.

Chemical and biological substances are controlled to guard against proliferation of the related weapons. The effectiveness of the controls is sometimes questioned<sup>7</sup> but the need seems to be widely recognized. A list of controlled items is found on the Commerce Control List (CCL). The list includes some seemingly harmless materials such as titanium, which has many applications, even in fishing lures. The CCL is updated frequently and exporters are advised to check the list prior to shipments so that unexpected fines are not levied.<sup>19</sup>

A relatively recent term in export control is the "deemed" export. This type of control seeks to limit the transfer of knowledge and capability by **individuals**. Regulations are changing frequently but in essence, foreign nationals cannot be taught, shown, etc, controlled technologies without prior approval. Immediate questions arise about controlling the technology inherent in traveling personnel, particularly those working for multinational corporations. One author describes an obvious dichotomy "how can technology be both shared with and protected from a multinational work force?"<sup>22</sup> When technology transfer of this kind occurs within U.S. boundaries, it is considered a "deemed" export. Some form of control has existed for military items in the past but the commercial aspects are just starting to be felt. Deemed exports are related to other control categories such as encryption. For example, because encryption controls were recently loosened, the deemed export license requests are expected to decline because less of the technology needs to be protected from foreign nationals. Therefore, fewer individuals possessing the technology are controlled. Some complaints have surfaced from industry on the timeliness of the license approvals (averaging nearly 2 months)<sup>14</sup> and on the subjective nature of the reviews.

### **Literature review**

A thorough search of recent literature (1995 and later) has resulted in dozens of articles related to export controls. The sources are truly diverse, perhaps more so than most established fields. A sampling of sources includes The New York Times, Journal of International Business, Network Security, Traffic World, International Review of Law Computers & Technology, Space Policy, Aviation Week and Space Technology, Business Week, Credit Control, Export Practitioner, The Economist, Management, Insight, and numerous others. One thing that clearly stands out is the lack of academic literature. A few journal articles discuss narrow areas of export controls, but there is a definite lack of rigorous study. Perhaps a half a dozen academic articles have appeared in research journals in the last 5 years, a time when many changes have occurred in export

control policy. Another indicator of literature coverage of this subject is the number of dissertations addressing export controls. There have been only eight dissertations on export control in the last 10 years.

It is not implied that other literature is not valuable. But certainly, without a foundation of tested theories and data, as found mostly in academic journals, hypotheses are difficult to test and theories are hard to defend. Also, without a foundation, a solid understanding of the factors and relationships of phenomena cannot be adequately developed.

Considering the **entire** body of recent export control literature, the following are the five most discussed topics in order of highest frequency: encryption, descriptions and status of current regulations, computers and computer security, arms/military, and case discussions.

### **Encryption**

This is **the** hot topic in export control. The reason for the attention is probably twofold. First, the explosion of electronic commerce. The increasing traffic of sensitive financial information will draw the hackers and crackers. To keep customer data safe, firms will need better tools to protect their information. Software developers are ready to meet the demands but are faced with a dilemma. Do they develop different versions of the software for use in different countries? That would be expensive and reduce cost sales. The largest software customers, the multinational firms, will be the most impacted. To compound this, law enforcement and government agencies want a back door into the data. If needed, they want to be decoding encrypted data within a matter of hours. How do you provide different levels of security by end user, provide quick access to authorized security personnel, and yet guarantee confidentiality to customers?

As mentioned earlier, the policy trend had been to gradually loosen controls (allow wider use of stronger encryption) but establish a key system for authorized agencies and trusted third parties to have backdoor access. This policy took a strong turn in late 1999 when a relatively free trade approach was adopted, at least for commercial end users. Literature is yet to comment.

Flux in encryption regulation is the second source of apparent interest. Literature is simply keeping up with the regulations, its enforcement, and likely future direction. Practitioners want to comply to avoid penalties and costly delays. Business also wants to be prepared for future requirements and ideally would like to influence the Regulations and Procedures Technical Advisory Committee (RPTAC)<sup>23</sup> (joint government/industry team recommending export control policy) in ways that benefit themselves. Therefore, literature in recent years has discussed encryption controls and argued why or why not limits should be adjusted. Much discussion has also centered on understanding the intent of policy or how policy stands up to challenges in court. It will be interesting to see reactions in the encryption field to the recent export control changes. It appears that much of what was important in recent articles just got swept away.

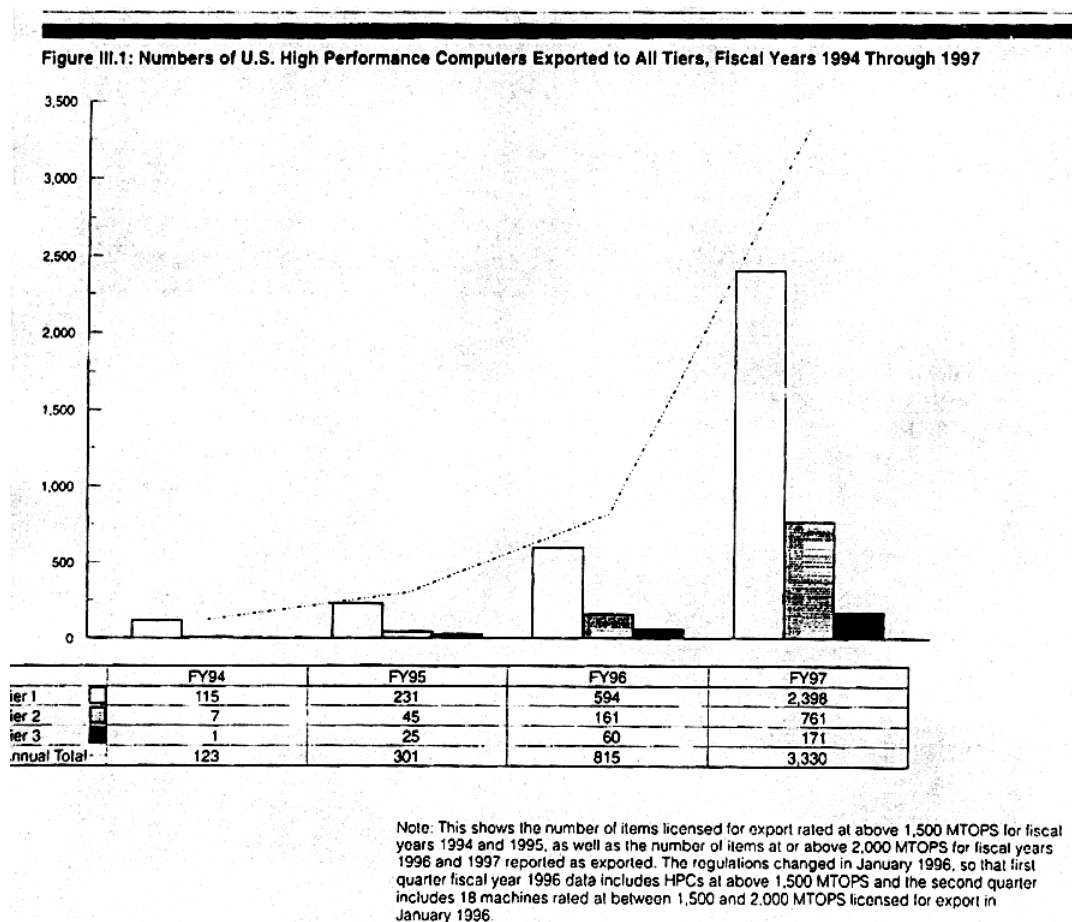
### **Descriptions of regulations**

Media, practitioner articles, and government information sources have all contributed to describing the status and direction of export control policy. This is understandable given the complexity of the issues and the broad application of export control. A spike in literature can be seen in the times when major changes were occurring or when unique events occurred such as

the espionage charges directed at China, or the nuclear testing by Far East nations. Although this literature may be valuable to current practitioners, it offers little explanation for anything but the most elementary aspects of export controls.

### Computers and computer security

Much of the debate on HPC and computer security relates to the level at which export licenses become a necessity. How much dampening of exports is appropriate? The exponential growth of computing capability (measured in MTOPS) has made it difficult for policymakers to keep current with business needs. Figure 1 shows growth in computing power. Figure 2 describes how many computers have been exported under recent licenses. The exponential growth of the curve in Figure 2 may be an indicator that controls have been too strict. New regulations have been released and will become effective in 2000 that raise the MTOPS level of computers permitted to be exported before licenses are required. This category of export control may be so active because of the dominant position that the United States holds in computing capability. Given that the US has lost its dominance in many fields to foreign competitors, it is logical to see concern both from industry and government. It is also undeniable that computers touch nearly every aspect of modern life. The nearness of the subject to so many people makes it newsworthy, hence, the abundance of literature.



**Figure 2. Exports of license-controlled computers<sup>27</sup>**

## **Arms/military**

This is a relatively broad literature category that encompasses dual-use goods, space items, and conventional arms. The discussions on dual-use goods typically revolve around the items falling within the controlled items list. With the reductions in military budgets and the growth of commercial high technology, dual-use goods are becoming more prevalent. So are the arguments of what should be controlled. The Department of Defense is accused of being overly conservative in its list of military products. The space-qualified items that are being considered for transfer from commerce to the State Department are one example that generates literature. An Aviation Week and Space Technology article highlights the government's limitations on space-related trade.<sup>11</sup> Another article quoted estimates that space revenues could be as high as \$200 billion in the year 2000.<sup>24</sup> I believe there is no doubt that the world is at the edge of a space commercialization thrust. Keen interest by all parties is understandable. Lost space technology may have enormous security ramifications but lost business opportunities will have equal economic consequences. This perhaps explains the volume of practitioner literature in this area.

Arms sales are another area of frequent literature. Conventional arms sales totaled \$34 billion in 1994. The United States was estimated to have 70 percent of world market at that time.<sup>25</sup> Pressure is expected to grow from the major competing nations in Europe, and especially Russia. Russia has a need for hard currency and also has a need to utilize its capital base. Literature on exports of conventional arms discusses the changes in world power structure and what that has meant to arms exporters like the United States, Russia and the United Kingdom. Literature also discusses the practice of "offsets." Offsets are agreements between a exporter and the receiving country that requires the exporter to return a percentage of the production covered in the contract back to the receiving country through subcontracts to local manufacturing. For example, a fictitious U.S. firm negotiates a \$10 billion contract for helicopter sales to a NATO ally, with a 50% offset agreement. Part of the deal will thus require the US firm to purchase 50 percent, or \$5 billion, of the parts/supplies from the ally country buying the helicopters. Offsets are getting closer scrutiny and in all likelihood will be restricted or eliminated if current trends continue.<sup>26</sup>

## **Why the limited academic interest?**

There are several possible explanations for the seeming lack of academic interest. First perhaps is the rapidly changing field. It becomes difficult to rigorously evaluate the success or impact of an export control policy when it keeps changing. The climate does not remain stable long enough for academics to develop and implement a socio-econo-political study. The game and the players change before the scores are tallied. Encryption control is a perfect example.

A second problem may be that political biases could be present in the data and processes. One of the challenges always faced by researchers is the validity of the data. The data used in deciding and evaluating policy is collected and reported by government agencies or industry associations. The current administration has a self-interest in reporting the data in a manner that supports their own views. Government reports can therefore be biased. Bias is clear from reading the BXA reports to Congress. The strong statements of success by the administration and the bashing of the opposition's arguments are clearly visible. Likewise, industry associations will depict a doom and gloom picture for their unique situation if it results in less red tape and government oversight.

The international ties may be another factor. Isolating or controlling variables may certainly be a research problem. Export Controls are not simply a decision made in the United States. The United States is a member of the Wassenaar Arrangement, which comprises 33 allied countries<sup>10</sup> that have multilateral agreements. This arrangement, started in 1996, is the successor of CoCom. The complexity of modeling such an interrelated and interdependent system may be too formidable given the dynamic nature of the problem.

Another possible factor is the seemingly small economic impact. Although there is debate as to how much impact export controls has on the U.S. economy, the exports that required licenses (or at least if licenses were filed for) encompassed approximately \$20 billion in 1999 or between 3 to 4 percent of total U.S. exports.<sup>14</sup> Exports in turn account for 7 to 8 percent<sup>1</sup> of total Gross Domestic Product (GDP). Certainly academics is more concerned with the remaining 99.8 percent of the economy.

Finally, some of the information that would contribute to understanding the problem may be classified. For example, the current level of encryption technology is classified. It is difficult, if not impossible, to assess the impact of transferring encryption technology of 64 bits if we do not know what the current U.S. capability is. If current capability were 64 bit also, we would experience a more significant setback relative to our adversaries by giving away that level of technology then if we had 1024 bit encryption/decoding capability.

None of these alone can explain the limited research. But all of these taken together, the difficulty of the problem, its dynamic character, the questionable or restricted data, and the relatively small impact on the overall economy, can perhaps explain the void in our rigorous understanding of the real impacts of export controls.

### **Where should academic research start?**

Five obstacles were identified in the preceding section that could potentially impact the academic research of export control. A logical approach to outlining a possible research agenda would be to start with the current barriers and explore ways to overcome, avoid or block them.

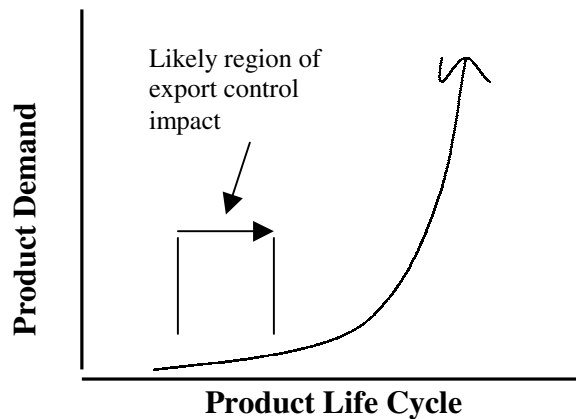
The first barrier discussed is the rapidly changing requirements. There are relatively few options when faced with such a research dilemma. One potential option may be to model the problem in general-enough terms that the details, the changes in the system, are diluted, at least for the time period of interest. In effect, elevate the analysis so that the changes become noise compared to the issues being studied. Of course this methodology will only go so far. Eventually, the high level theories need to be refined for practical benefit and for that, details are important. Fortunately there is room in this topic for such theory-building methods. Another potential option may come out of the fact that many of the export-controlled products fall into a few distinct homogeneous categories. There are the HPCs, encryption technology, and conventional arms. At the category level it may be that models could be developed for predicting economic impacts of either delaying or denying exports given a competitive international market. A drawback of this potential approach is that it only would apply to clear categories and not for the dual-use technologies or others that cannot be clearly identified.

Another opportunity for research is the prediction export control impacts using modern forecasting techniques. By very nature, export controls apply to the cutting edge of applied knowledge. It would seem reasonable that export control could be an application ground for certain judgmental forecasting methods. Cross Impact and Delphi or Scenario Analysis forecasting are possible methods to explore. These judgmental forecasting methods could be used to predict the impact of export control legislation on both industry and national security. Benefits will come from academic research when government and industry are better able to predict the future outcome and cost of today's decision.

A second concern of academics may be the validity of the data. Academics are very sensitive to the garbage in/garbage out phenomena. The whole notion of testing surveys stems from an attempt to capture and use only that information which accurately reflects the topic under study. In other academic fields special data sets are generated and tested. These are then used by numerous researchers in testing their hypothesis. This ensures that the models become the discriminators of the outcome and not the unique data. The same is true for surveys, which are simply a tool to gather the desired data. It seems logical that export control should follow the same pattern. A second data-related challenge is the validation of data coming from the field. An identification of the best sources of information, methods of cross-checking, and quantification of biases are some of the areas needing work.

The third possible concern mentioned was the complexity brought on by the international ties. The sovereignty of participating nations eliminates a true single decision maker. Due to the infancy of our understanding of export controls, it is suggested that models and theories be first developed for a single independent government and its encompassed industries. The extension to multiple nations should wait until a better theory base is laid.

The "small" economic value of the export-controlled items was identified as another reason why academic research is limited. Data suggests that only 3 to 4 percent of total exports fall into controlled categories.<sup>14</sup> I suggest however, that a more thorough analysis of export control impacts is needed. As stated several times, export-controlled items are cutting edge, high-tech items. Although not completely understood, it is generally accepted that high-tech products follow an "S-shaped" growth curve. Initially there is slow growth as the product is introduced and sold only to a few specialty users. A strong period of growth then occurs followed by a slow-down in growth as the market becomes saturated. This pattern is often mathematically modeled by Logistic or Gompertz curves. Because export-controlled items are the "advanced" products they are at the bottom, slow growth portion of the curve (when export impacts would generally be estimated). The growth rates are low in the early stages of introduction. The predictions of the impacts of export controls can therefore be seriously underestimated. Refer to Figure 3.



**Figure 3. Export relevant region of product demand cycle**

It is suggested that standard methods of reporting exports do not adequately capture the information necessary to understand the real impact of delaying or denying the exportation of high-tech products. An example of our disposition for linear estimating is seen in a technical report published by the NAVAL Research Laboratory<sup>28</sup> on encryption. The approaches used in the parametric estimating are linear or a log-linear hybrid. In reality the curves are probably exponential. One approach to estimate potential impact of exports is to use historical information like prior year exports. However, posting dollar values of last year's exports simply will not tell us what future impact the limiting of sales has, particularly when foreign competitive products are looming closely behind. I propose that export controls on high-tech products have a much greater impact than commonly believed.

The classified status of some of the relevant data may be another deterrent to academics. More off-the-shelf products are replacing custom military products. Classified items may be becoming less common but at the same time proprietary data is replacing them. Therefore, if restricted data is a significant factor it will likely remain so. There does not appear to be a way to work around this problem. Perhaps, new research can help quantify to what extent restricted data hinders our ability to understand the impact of export controls.

To summarize, academic research is needed and should begin with (1) checking the available data for bias and identifying standard sources for cross-checking, (2) developing standard data sets, based on realistic product growth curves (not necessarily straight line) for model testing, (3) identifying the characteristics of the relatively homogeneous controlled product groups (encryption, HPCs, conventional arms), (4) experiment with judgmental forecasting methods to study and predict security and economic impacts of export control decisions, and (5) determine what impact restricted data may have on the general export control "problem."

## **Conclusion**

Export control is the restriction placed on technology that is believed to offer a military advantage to the home country. Currently, controls use both end user and product filters. Encryption technology, HPCs, conventional military items, deemed exports, and dual use products are main areas of focus. Restrictions are tighter against military users, disfavored



nations, and known entities that are involved in military or terrorist activities. Export controls affected approximately \$20 billion worth of exports in 1999. A key to understanding the real economic impact of this figure may be to realize that the products controlled are typically at the bottom of an “S-shaped” growth curve. Unless this is recognized, long-term impacts may be severely underestimated. Surprisingly little academic research has been done on export controls. There are several possible explanations: (1) the dynamic nature of the field, (2) the unvalidated data, (3) the complexity of the issues, especially considering the international interactions, (4) small apparent economic impact, and (5) some classified data. Future academic research must overcome these barriers. A suggested approach is to begin by testing and developing data that can be a basis for future hypothesis and model testing. Next, research should combine judgmental forecasting with export control problems and use homogeneous controlled product categories to generate theories and models. Classified information may impact export controls; this hypothesis should also be tested and explained.

## References

1. Kuttner, Robert, How “National Security” Hurts National Competitiveness. Harvard Business Review, Jan.–Feb. 1991.
2. Flamm, Kenneth, Controlling the uncontrollable. The Brookings Review, Winter 1996.
3. Reinsch, A. William, a speech at a Bureau of Export Administration conference, Bureau of Export Administration Records. February 2000.
4. Smith, Charles, Clinton Profiteers Sell High-Tech to Red China, Insight, December 22, 1997.
5. Anonymous, Aviation Week & Space Technology, Update—U.S. Technology Export Controls, April 2000.
6. Ackerman, M. Wistan, Encryption: A 21st century national security dilemma, International Review of Law, Computers & Technology, July 1998.
7. Biederman, David, Export Controls, Part 1, Traffic World, May 24, 1999.
8. Anonymous, Jurisdictional Review of “Space Qualified” Items, BXA website: <http://www.bxa.doc.gov/licensing/SpaceQualifiedReview.html>, Spring 2000.
9. Anonymous, BXA Annual Reports to Congress, BXA website: <http://www.bxa.doc.gov>, Spring 2000.
10. Anonymous, National Security Export Controls and the Wassenaar Arrangement, BXA website: <http://www.bxa.doc.gov/Wassenaar/>, Spring 2000.
11. Mann, Paul, Lawmakers Clobber Satellite Exports, Aviation Week & Space Technology, June 28, 1999.
12. Anselmo, C. Joseph, Hamre: Export Delays Hurting US Alliances, Aviation Now, November 8, 1999.
13. Anonymous, US Commercial Technology Transfers to the Republic of China, BXA Report, 1997.
14. Majak, R. Roger, a speech at BXA conference, February 2000.
15. Biederman, David, Export Controls, Part 3, Traffic World, June 7, 1999.
16. Anonymous, “Deemed Exports” Questions and Answer, BXA website: Spring 2000.
17. Biederman, David, Inside the OEE, Traffic World, July 12, 1999.
18. Anonymous, Export Controls Loosen Despite China Concern, U.S. News & World Report, July 12, 1999.
19. Biederman, David, BXA: Know your end-user, Traffic World, July 13, 1998.

20. Anonymous, Federal Register, Revisions to Encryption Items, 15 CFR parts 734, 740 et al., January 14, 2000.
21. Anonymous, Federal Register, Revisions to High Performance Computing Licensing Policy, 15 CFR parts 734, 738, 740 and 742, August 3, 1999.
22. Biederman, David, Deemed Exports, Traffic World, March 15, 1999.
23. Biederman, David, The RPTAC, Traffic World, December 20–27, 1999.
24. Dula, Art, Space Law for Business Profits from proceedings of the International Conference and Exhibition on the Commercial and Industrial Uses of Outer Space, June 1986.
25. Neumann, G. Robert, Conventional arms exports and stability in the Middle East, Journal of International Affairs, Summer 1995.
26. Reinsch, A. William, a presentation at a Bureau of Export Administration Offset Summit, “The Challenge of Free Trade” Bureau of Export Administration Records. January 2000.
27. Anonymous, Export Controls - Information on the Decision to Revise High Performance Computer Controls, Congressional Report, September 1998.
28. Keuthan, M. Lynn, Digital Telephony Analysis Model and Issues, Technical Report of the Naval Research Laboratory, September 1995.

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